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Reactive Navigation of Multiple Moving Agents in a Room Environment

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Abstract: Navigation of mobile robots in unknown environments is one of the most research areas. Mobile robot can be used in many applications such as indoor and outdoor security patrols, material transport.The Collision avoidance implementation will take advantage of embedded system implementations based on the Renesas microcontroller, RL78/G13, with interactivity to an wireless communication technology called ZigBee technology which will be responsible for assisting the robots in avoiding objects in its path of motion. The proposed project takes advantage of the emerging Radio Frequency Identification (RFID) technology to guide the robot to navigate in its working space. The main advantage of this project is, since Zigbee is bi-directional wireless communication technology provides data integrity check and authentication. Transmitting and receiving information has lower power consumption.

Keywords: Renesas microcontroller, IR and PIR sensors.

I. INTRODUCTION

Multi robot systems have become an active area of research since it facilitates improved efficiency, faster response due to spread of computational burden, augmented capabilities, and discovery of emergent behaviour that arise from interaction between individual behaviours. Multiple mobile robot systems is found in applications, and in many areas such as material handling operations in difficult or hazardous terrains, fault-tolerant systems, covering and exploration of unmanned terrains, and in cargo transportation.

Collaborative Collision Avoidance(CCA) between robots arises in many such multi robot applications where robots need to crisscross each other's path in rapid succession or come together to a common location in large numbers. Whether it is a case of navigation of robots in a rescue and relief operation after an earthquake or while searching the various parts of building or in the case of fully automated shop floor or airports where there are only robots going about performing various chores, CCA becomes unavoidable.

This proposal is mainly designed to avoide collision whenever the robots are left free to move in their path that is from source to destination. Robot is provided with IR sensor to detect obstacle and PIR sensor to detect human motion.

II. METHODOLOGY

1. In order to avoid collision between two robots, RFI
2. D tags are placed in their path.
3. The master robot is made intelligent such that the whenever there is slave robot comes in the path of master robot, slave robot will give priority to master robot to cross first. The slave robot will wait and it will pass later. This is obtained by making the robots to communicate with each other.
4. Referring to figure 1.1 shown below, now suppose master wants to move from RFID TAG3 to RFID TAG4 that is from source to destination, and at the same time if the slave wants to move from RFID TAG1 to RFID TAG2 then both the robots must cross RFID TAGX. So there is certainty that they will collide, at this point we give priority to the master to move. The master will send information to slave that is at RFID TAGX. As soon as the message is received by slave, it will slow down and stop.

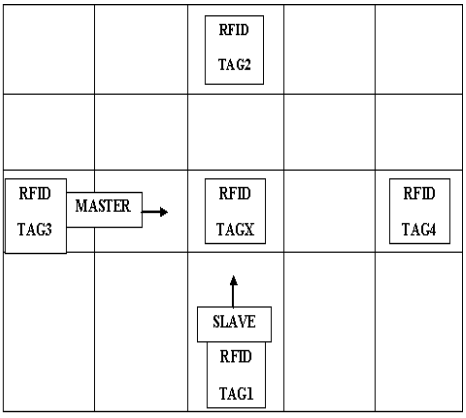

Fig 1.1 Robot Navigation in a Room Environment.

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5. When master crosses RFID TAGX, it will communicate with slave using ZigBee. As soon as slave receives the message it starts to move and reaches its destination (RFID TAG2).
6. The slave robot is provided with IR sensors which will detect the obstacles from four directions and avoid collision with all other robots. It is also provided with PIR sensors, it detects human. When human passes in front of the robot the PIR sensor generates a high on its output and simultaneously sends message to the provided mobile number using GSM and LCD is used to display the message.

III. RADIO FREQUENCY IDENTIFICATION TECHNOLOGY

A. DESCRIPTION OF RFID

Radio Frequency Identification or RFID has sprung into prominence in the recent years with the promise of providing a relatively low cost means for connecting non-electronic objects to an information network. Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. The technology requires some extent of cooperation of an RFID reader and an RFID tag.

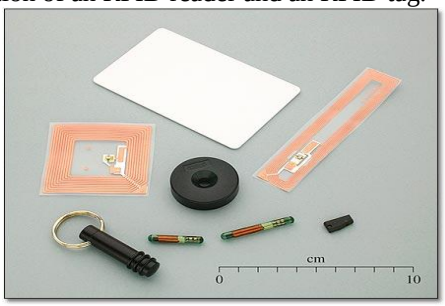

Fig 3.1 Variety of RFID Tags

RFID systems rely on the use of a radio communication channel for their operation. This has a number of implications relating to the security of system operation. RFID enables identification from a distance, and unlike earlier bar-code technology, it does so without requiring a line of sight. RFID tags support a larger set of unique IDs than bar codes and can incorporate additional data such as manufacturer, product type, and even measure environmental factors such as temperature. Furthermore, RFID systems can discern many different tags located in the same general area without human assistance.

At its most simple, radio frequency identification (RFID) system consists of two components, namely a tag (also called a transponder) as shown in fig 3.1 and a reader (also called an interrogator).

An RFID tag is an object that can be applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves.

There are many different types of RFID systems out in the market. They are categorized according to their frequency ranges. Some of the most commonly used RFID kits are as follows:

1. Low-frequency (30 KHz to 500 KHz)
2. Mid-Frequency (900 KHz to 1500MHz)
3. High Frequency (2.4GHz to 2.5GHz)

These frequency ranges mostly tell the RF ranges of the tags from low frequency tag ranging from 3m to 5m, mid-frequency ranging from 5m to 17m and high frequency ranging from 5ft to 90ft.

B. Near-field Coupling

Faraday's principle of magnetic induction is the basis of near-field coupling between a reader and tag. A reader passes a large alternating current through a reading coil, resulting in an alternating magnetic field in its locality. If you place a tag that incorporates a smaller coil in this field, an alternating voltage will appear across it. If this voltage is rectified and coupled to a capacitor, a reservoir of charge accumulates, which you can then use to power the tag chip.

Tags that use near-field coupling send data back to the reader using load modulation. Any current drawn from the tag coil will give rise to its own small magnetic field-which will oppose the reader's field. The reader coil can detect this as a small increase in current flowing through it. This current is proportional to the load applied to the tag's coil (hence load modulation).Thus, if the tag's electronics applies a load to its own antenna coil and varies it over time, a signal can be encoded as tiny variations in the magnetic field strength representing the tag's ID. The reader can then recover this signal by monitoring the change in current through the reader coil.

C. Infrared (IR) Sensor

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. It is also capable of measuring heat of an object and detecting motion. Infrared waves are not visible to the human eye.

In the electromagnetic spectrum, infrared radiation is the region having wavelengths longer than visible light wavelengths, but shorter than microwaves. The infrared region is approximately demarcated from 0.75 to 1000µm. The wavelength region from 0.75 to 3µm is termed as near infrared, the region from 3 to 6µm is termed mid-infrared, and the region higher than 6µm is termed as far infrared. Infrared technology is found in many of our everyday products. For example, TV has an IR detector for interpreting the signal from the remote control. Key benefits of infrared sensors include low power requirements, simple circuitry, and their portable feature.

The basic idea is to send infrared light through IR-LEDs, which is then reflected by any object in front of the sensor. For detecting the reflected IR light another IR-LED is used, to detect the IR light that was emitted from another LED of the exact same type.

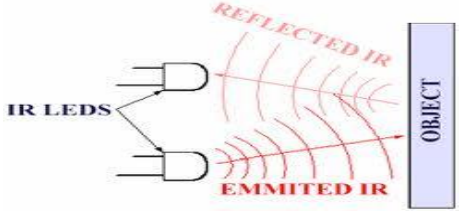

Fig 3.2 Detection of object using IR sensor

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This is an electrical property of light emitting diodes (LEDs) which is the fact that a LED produces a voltage difference across its leads when it is subjected to light, as if it was a photocell, but with much lower output current. Fig 3.2 shows the obstacle detection using IR sensor. In other words, the voltage generated by the LEDs cannot be in any way used to generate electrical power from light, it can barely be detected. That is why as you will notice in the schematic we are going to use an Op-Amp to accurately detect very small voltage change.

D. Passive Infrared (PIR) Sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors.

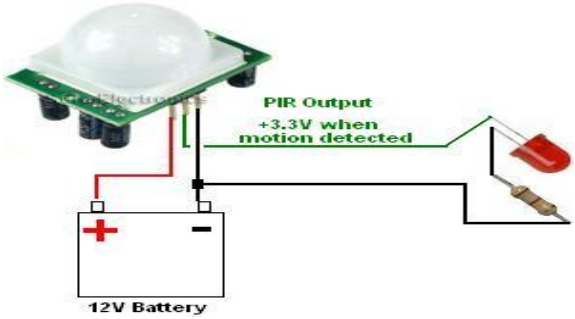

Fig 3.3 Typical PIR sensor module

The term passive refers to the fact that PIR devices do not generate or radiate any energy for detection purposes. They work entirely by detecting the energy given off by other objects or passively accept incoming radiation. Fig 3.3 shows a typical PIR sensor.

On closely observing the top region of the sensor, the beehive structure, curved segments are seen. These curved segments are Fresnel lenses which constitute an array that increases the detection zone of the sensor. Fresnel lens array is known to capture more infrared radiation and focus it to a relatively smaller point. Detection is more stable and maximum distance for detection is also increased. Fresnel lens has been crafted to be translucent so that it can capture only infrared radiation without getting unwanted radiations from visible spectrum of light.

The sensor can sense change in infrared energy within small distances of about 10 inches. Human body radiates IR waves with wavelengths of 8 to 12 micrometre. Apparent motion is detected when an infrared emitting source with one temperature, such as human body, passes in front of source with another temperature, such as wall. The unit output is high whenever there is motion detected.

IV. HARDWARE IMPLEMENTATION

4.1Principle of Operation

Collaborative Collision Avoidance (CCA) between two robots becomes necessary and unavoidable. In order to avoid collision between the two robots the communication between them is necessary. The block diagram of slave robot is shown in Fig 4.1.1

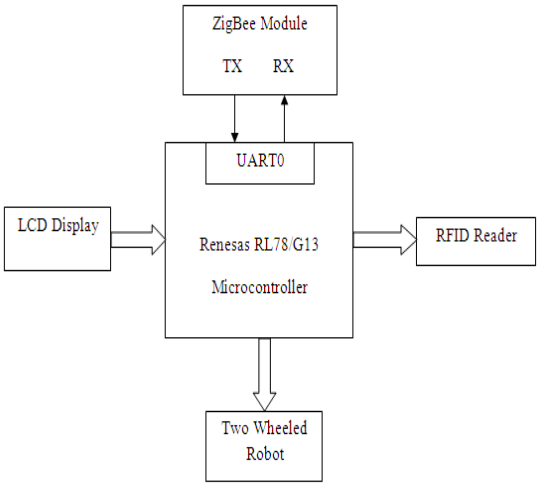

Fig 4.1.1 Block Diagram of Master Robot

A wireless technology, ZigBee, designed with unique needs of low cost, low power wireless sensor network is used to establish proper communication between the robots. This ZigBee- technology is easy to implement and needs less power to operate.

Two robots are left free to move in their path, RFID tags are placed in their path, the RFID readers in the robot detect the tags. This RFID technology requires some extent of cooperation of RFID reader and RFID tag. In this project passive tag is used. The tag reader is responsible for powering and communicating with a tag. The block diagram of slave robot is shown in Fig 4.1.2. If one robot comes in the path of other robot, one robot takes priority to pass first and other will wait and pass later.

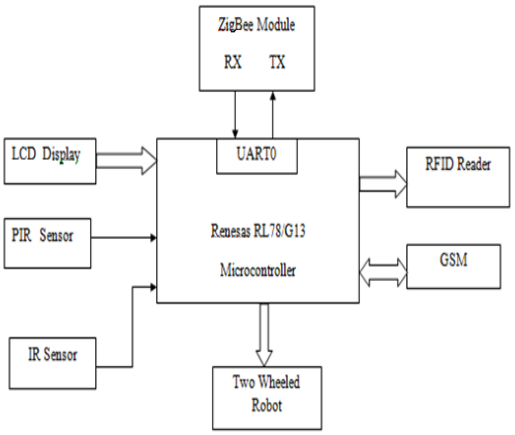

Fig 4.1.2 Block Diagram of Slave Robot

Zigbee is used for one to one communication between the robots, it communicates through UART0 of Renesas microcontroller. IR sensor is used here to detect the obstacle. The robot is also provided with PIR sensors, it detects human. PIR sensors work entirely by detecting the energy given off by other objects or passively accept incoming radiation. Simultaneously it will send the message to the provided mobile number using GSM through UART1 of microcontroller and LCD is used to display the message. The robots are provided with motor driver circuit (L293D) which allows DC motor to drive on either direction.

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4.2 Renesas RL/78 Microcontroller (R5F100LEA)

Renesas, the world's number one microcontroller supplier and manufacturer, offers the widest choice of microcontroller (MCU) and microprocessor (MPU) solutions, comprising 8-bit, 16-bit and 32-bit MCU and MPU families. The Renesas microcontroller and microprocessor portfolio offers the most scalable MCU/MPU platforms available, offering low power, high performance, small packages and the largest range of memory sizes combined with feature-rich peripherals.

Fig 4.2.1: RL78/G13 (R5F100LEA) Microcontroller Board

4.3 Liquid Crystal Display (LCD)

LCD screen is an electronic display module which has a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multisegment LEDs.

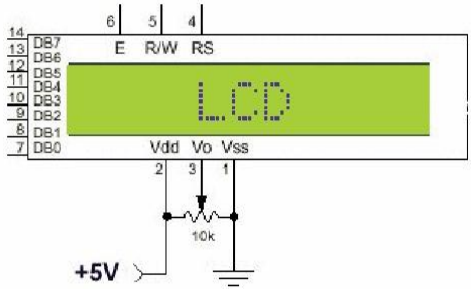

Fig 4.3.1 Pin Description of 16 x 2 LCD Display

The command register stores the command instructions given to the LCD. The Fig 4.3.1 shows the Pin Description of 16x2 LCD Display. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register storesthe data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

There are three signals in the LCD:

1. Enable (E): This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled. When it is high, the LCD checks the state of the two control lines and responds accordingly.
2. Read/Write (R/W): This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.
3. Register Select (RS): With the help of this line, the LCD interprets the type of data on data lines. When it is low, command register is selected i.e. an instruction is being written to the LCD. When it is high, data register is selected i.e. a character is being written to the LCD.

4.4 ZigBee

ZigBee is the only standards-based wireless technology designed to address the unique needs of low-cost, low-power wireless sensor and control networks in just about any market. ZigBee is based on IEEE 802.15.4 standard for Low Rate Wireless Personal Area Network (LR-WPAN).

Fig4.4.1: ZigBee Board

Data enters the module UART through the DIN (pin 3) as an synchronous serial signal. The signal should idle high when no data is being transmitted. Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.The module UART performs tasks, such as timing and parity checking, that are needed for data communications. Serial communications depend on the two UARTs to be configured with compatible settings (baud rate, parity, start bits, stop bits, data bits).

4.5 Motor Driver Circuit (L293D)

L293D is a dual H-bridge Motor driver or Motor Driver IC which allows DC motor to drive on either direction. Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.

V. SOFTWARE IMPLEMENTATION

1. Embedded C

The C programming language is the most popular programming language for programming embedded systems. C programming is a general purpose, block structured, procedural, imperative computer programming language developed in 1972 by Dennis Ritchie at the Bell Telephone Laboratories for use with the UNIX operating system. Although C programming was designed for implementing system software, it is also widely used for developing application software. C programming is a high level programming language that is portable across many hardware architectures. This means that architecture specific feature such as register definitions initialization and start up code must be made available to our program via the use of libraries and includes files.
C programming remains a very popular language for microcontroller developers due to the code efficiency and

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reduces overhead and development time. C programming offers low-level control and is considered more readable then assembly. Many free C compilers are available for a wide variety of development platforms. The compilers are part of an IDEs with ICD support, breakpoints, single-stepping and an assembly window. The performance of C programming compliers has improved considerably in recent years,and they are claimed to be more or less as good as assembly. Most tools now offer options for customizing the compiler optimization. Additionally, using C programming increases portability, since C code can be compiled for different types of processors.

2. Cube Suite+(IDE)

Cube Suite+ is an integrated development environment that provides an environment for developing microcontrollers from creation of pin lists to code generation, build and debug all in one tool. Cube Suite+ can run all the operations needed for developing the programs such as designing, cording, building, debugging, and flash programming.

VI. ADVANTAGES OF RFID TECHNOLOGY

1. No "line of sight" requirements: Bar code reads can sometimes be limited or problematic due to the need to have a direct "line of sight" between a scanner and a bar code. RFID tags can be read through materials without line of sight.
2. More automated reading: RFID tags can be read automatically when a tagged product comes past or near a reader, reducing the labor required to scan product and allowing more proactive, real-time tracking.
3. Improved read rates: RFID tags ultimately offer the promise of higher read rates than bar codes, especially in high-speed operations such as carton sortation.
4. Greater data capacity: RFID tags can be easily encoded with item details such as lot and batch, weight, etc.
5. "Write" capabilities: Because RFID tags can be rewritten with new data as supply chain activities are completed, tagged products carry updated information as they move throughout the supply chain.

VII. CONCLUSION

This is useful in areas where robots are allowed to perform specific task but humans are restricted. In this project, we studied about the motion strategies that rely on sensory information to compute the movements according to the unforeseen circumstances. These strategies are the sensor-based motion planning methods (also named reactive navigation methods). The main advantage of our project is that it employs the strategy to reduce the difficulty of the navigation and path planning problem in mobile robots. As a consequence, the reactive navigation methods are implemented successfully navigates in more troublesome scenarios than other existing methods.

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BIOGRAPHIES

Dr M Shiva Kumar did his M.Tech in 1998 and Ph.D. in 2011 from University of Mysore. He has a teaching experience of more than 20 years. At present, he is working as Professor and Head in the department of Telecommunication Engineering of GSSS Institute of Engineering and Technology for Women, Mysore. He has published several papers in international conferences and journals. His areas of interest include Speech Signal Processing and Mobile Robotics.

Mr. M. V. Sreenivas Rao, did his M.Tech in 2008 and pursuing Ph.D. in the area of Robotics from VTU. At present, he is working as Associate Professor& Head, Dept of Electronics and Instrumentation Engineering, GSSS Institute of Engineering & Technology for Women, Mysore. His areas of interest include mobile robotics, smart sensors and MEMS.

Mr Stafford Michahial did his M.Tech in 2012 and pursuing Ph.D. in the area of Medical Image processing from VTU. At present, he is working as Asst. Professor in the department of Telecommunication Engineering of GSSS Institute of Engineering and Technology for Women, Mysore. He has published several papers in international conferences and journals. His areas of interest include signal and image Processing and AI Robotics.